Envelope: T-Bar Ceilings

Description

This measure prohibits the installation of "lay-in" insulation on top of removable ceiling tiles. Insulation that is counted towards calculating the overall thermal resistance of the roof must be at the roof deck, unless the ceiling is permanent (i.e., does not have readily removable tiles) and forms an air barrier. The walls above the ceiling tiles will be walls of the conditioned space and will be required to be insulated.

Benefits

This measure will reduce heat transfer from the outside to the conditioned space due to increased effective R-value of the insulated roof and sidewalls above the T-bar ceiling and decreased infiltration. Placing the thermal insulation at the roof deck instead of the ceiling plane will also increase the effective duct efficiency. Since the ducts will now lie within the thermal envelope, duct losses will help condition the space. Also, the duct temperature will be closer to the temperature of an insulated plenum than that of an attic space over a lay-in insulated ceiling as a result of this measure – reducing non-leakage losses into the plenum. This will further decrease heating and cooling energy consumption and the peak electrical demand needed to cool the building during the hottest times of year.

Moreover, most acoustic tile manufacturers do not recommend the use of insulation on top of these tiles because the additional weight can result in the tiles bowing over time. This is especially true if the insulation has to be compressed between the tile and building services in the plenum space.

Environmental Impact

In addition to the environmental benefits that flow from a reduction in energy consumption, limiting the use of lay-in insulation reduces the exposure to fiberglass fibers. Inhaling fiberglass can cause lung damage and other respiratory disorders, but this risk can be mitigated with encased batts. There are two scenarios for reduced exposure to fiberglass:

1. Exposure of maintenance personnel when replacing or repairing equipment in the ceiling plenum. Greater exposure to fiberglass fibers is encountered when insulation is draped over the ceiling than when the insulation is attached to the underside of the deck or insulation above the deck.
2. Potential exposure of the occupants when the HVAC system is retrofitted to a plenum return system or a plenum return system is added. Although exposed insulation in plenum return systems is in violation of code, some of these systems may get still get installed and the fiberglass fibers could then circulate into the conditioned space of the building through the HVAC unit.

Type of Change

The proposal for lay-in insulation would disallow insulation over ceilings other than continuous ceilings that cannot be readily removed. This would be a mandatory measure.

This measure would affect the nonresidential section of the *Standards* and the Nonresidential Manual. These current *Standards* will revert to the language and descriptions similar to the 1992 Title 24 Standards.

This measure does not impact the performance method and thus does not affect the computer programs or the ACM Manual.

Measure Availability and Cost

Insulating the underside of the roof deck or insulating between the roof deck and the roofing material is the typical method of insulating roofs in nonresidential buildings. Two recent building research programs in

California have found that lay-in insulation is used approximately 5-10% of the time[1]. Thus the alternatives to lay-in insulation are readily available and commonly used.

Useful Life, Persistence and Maintenance

Insulation placed above or below the roof deck has more persistence than lay-in insulation. Building researchers are finding that typically all recessed troffers are uninsulated, creating large gaps in the lay-in insulation. Further gaps in lay-in insulation may occur because of the presence of interfering equipment in the plenum. Often, repair or maintenance personnel may toss aside some lay-in insulation to gain access to the plenum. This too results in patchy insulation, considerably lowering the effective R-value. Thus, lay-in insulation has less persistence than under deck insulation.

Performance Verification

Verification of insulation being installed is no different from what is currently required for most nonresidential buildings.

Cost Effectiveness

The measure is likely to be cost effective in most buildings. The prohibition against lay-in insulation will not be cost effective in buildings where the plenum space is exceptionally high. In these cases, the effective UA of the building may actually increase because the impact of the increased surface area within the thermal boundary may offset the positive impact of the lowered effective U-factor of the new insulation. The analysis will examine the significance of additional losses that may result from air leakage through the tiles, ventilation of the attic, or conduction losses through HVAC ducts. If these appear significant, the analysis will account for these effects in determining the appropriate insulation alternatives to be in the standards.

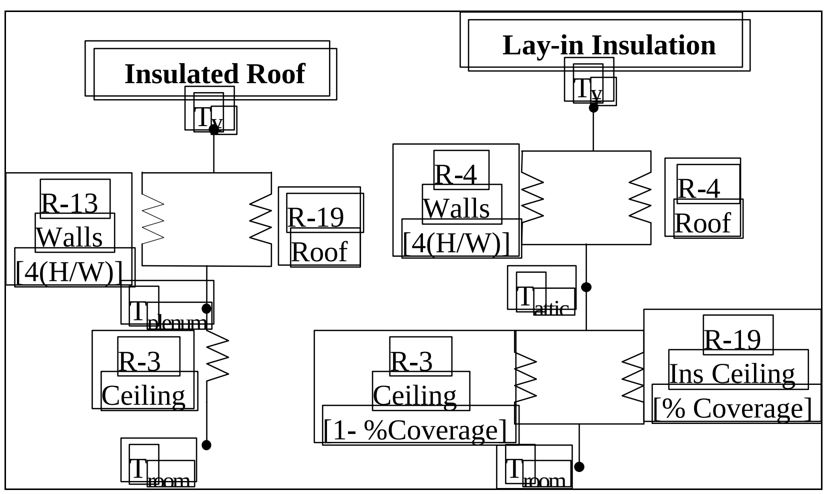

Figure 1: Thermal Network of an Insulated Roof vs. lay-in Insulation

Figure 1 illustrates the thermal networks used to evaluate the effective thermal resistance of a buildings with (1) insulated walls and roof deck and (2) lay-in insulation over the ceiling with various degrees of coverage. Note that this thermal network does not consider air leakage through the tiles, ventilation of the attic, or conduction losses through HVAC ducts. All of these factors would reduce the effective resistance of the lay-in insulation more than that of the insulated roof deck. Thus this analysis is very conservative and underestimates the savings from insulating the roof deck.

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[1] Results of a phone interviews with 200 commercial building managers for the PIER Integrated Design of Commercial Building Ceiling Systems project and from 40 on site surveys of commercial buildings for the PIER Integrated design of Small Commercial HVAC project.

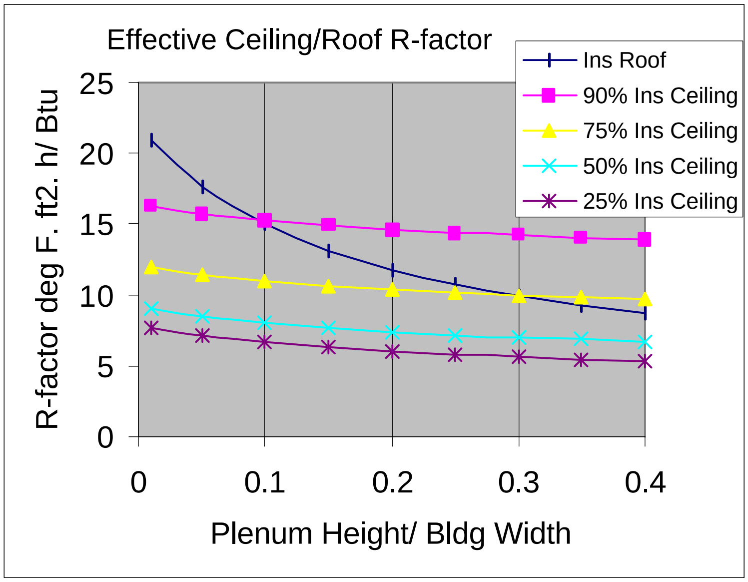

Figure 2: Effective R-values of Ceiling/Roofs for Different Plenum Heights and for different coverage of lay-in insulation

Lay-in insulation performs poorly for many building configurations and insulation coverages. Figure 2 plots the effective R-factor of these two competing methods of roof insulation. This analysis was done for buildings with a square shaped plan (building length = building width), and a flat roof. As the plenum height gets larger for a given building one would move to the left on the x-axis. Thus a square building with dimensions of 60 feet per side with an 18-foot tall plenum (0.3 plenum height /width) with an insulated roof deck would have the same effective roof/ceiling R-value of the same building containing lay-in insulation that covered 75% of the ceiling. For the same building with lower plenum heights the insulated roof would perform better than lay-in insulation with 75% coverage. Note that the largest coverage shown for lay-in insulation is 90% - this corresponds to 4 ft x 2 ft troffers on 8 ft x 10 ft spacing (the troffer space being uninsulated). Lower coverage values result from some additional tiles being uncovered.

Analysis Tools

DOE-2 is the likely simulation tool for estimating energy savings, peak demand reductions, and the TDV energy benefits that result from changes in insulation position. We will be reviewing the appropriateness of using the spreadsheet used by Mark Modera to evaluate the benefits of duct sealing. If this allows us to model the effects of lay-in insulation with sufficient reliability, we may use this approach.

Relationship to Other Measures

This measure significantly impacts the savings from sealing and insulating HVAC ducts. For many rooftop units most of the sealing and conduction losses occur in the area between the roof deck and the ceiling. If these losses occur within the thermal boundary of the building (when the roof deck and plenum walls are insulated) then these losses will contribute to the conditioning of the building.

Bibliography and Other Research

The PIER Integrated Design of Commercial Building Ceiling Systems has initiated research into this issue. This project has established an advisory group that includes representatives of the insulation and T-bar ceiling industries. In addition, this project has interviewed building managers of 200 randomly selected commercial buildings in California. Jon McHugh at HMG is the element lead for this project.

Mark Modera, at LBNL and Carrier, who has been researching duct sealing for several years, has been involved with the research for this measure. His model of energy savings from duct sealing is impacted by the placement of the thermal boundary. His model will be reveiwed to determine its potential use for this project.

Architectural Energy Corp, who are leading a PIER small rooftop efficiency project, have also been contacted. Discussions with Peter Jacobs of AEC have determined that moving the insulation to the roof deck will substantially reduce the energy losses from ducts.